Novel Method of Ethanol/Water Separation with Nanoporous Polymer Membranes

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Background

Bioethanol is an economical and environmentally friendly biofuel that has emerged as a sustainable fuel source. Fermentation is an attractive process for producing bioethanol, but requires costly product separation due to the low concentration of the fermentative products. Nanoporous polymer membranes have recently been explored not only in separating water from dissolved solutes in fermentation systems such as this, but also in liquid water purification and desalination. However, attempts at either result in the same problem - current nanoporous polymer membranes do not have well-defined pore pathways or uniform pore sizes on the nanometer level to give clean molecular separations. For separations such as ethanol/water separation to be effective, pore sizes on the <0.5 nm scale are needed. However, the ability to manufacture membranes with smaller pore sizes is increasingly more difficult as the pore size becomes smaller.

Recently, a method for generating membranes with uniform sub-1-nm pores was developed by cross-linking amphiphilic monomers to form a polymer membrane in the type I bicontinuous cubic (QI) lyotropic liquid crystal (LLC) phase. While this technique has been proven effective with desalination, the resulting pore size of 0.75nm in these first-generation QI-phase LLC polymer membranes is not small enough for light gas separation, and does not allow for controllable, uniform pore sizes below 0.75nm for even finer size-based separations of smaller water-soluble ions.

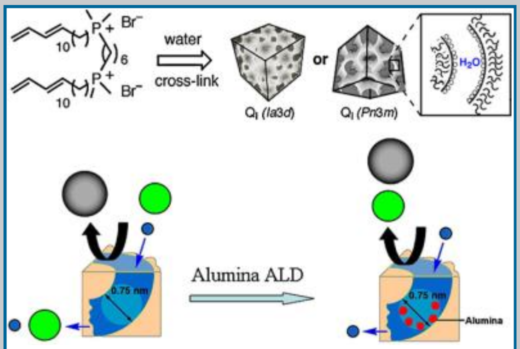

Fig. 1. Structure of the cross-linked QI-phase and the schematic representation of an alumina ALD-modified QI-phase LLC polymer membrane.

Technology

A University of Colorado research team led by Richard Noble and Douglas Gin has developed a novel method of modification for the existing technology, which creates nanoporous polymer membranes with smaller, uniform, and controllable pathways for light gas/water separation. By post treating QI-phase LLC polymer membranes by way of atomic layer deposition (ALD), for which the coatings are precisely controlled at sub-nanometer thicknesses, researchers were able to deposit ultra-thin ceramic films or ceramic clusters (alumina and titania) inside the porous structure of Q1 LLC membranes. The ALD-modified polymer membranes show great promise in various gas separations as they have an effective pore size smaller than 0.55nm. This approach also has the potential to modify other nanoporous membranes for size-selective separation.

Key Documents

Modification of nanoporous supported lyotropic liquid crystal polymer membranes by atomic layer deposition. Journal of Membrane Science. 2010 March;349(1-2):1-5. *PDF available upon request.*

"Novel Nanoporous Supported Lyotropic Liquid Crystal Polymer Membranes and Methods of Preparing and Using Same." U.S. patent application filed November 23, 2011; available under CDA.